central cross, and so arranged as to form a symmetrical interlacing design, or ribbon pattern. The arms of the cross are bisected by the sides of a lozenge-shaped figure enclosed within the rectangle, the whole presenting the appearance of an elegant knot. Fig. 2 in the same group represents a primitive cross enclosed within a quadrangle, and enriched with work of early Greek, or rather Etruscan design—a style of ornament, however, which is sometimes found in connexion with monumental slabs of early Christian times. Almost touching these crosses are a number of crosslet scorings (Fig. 3) which at first sight present in some degree the appearance of a species of oghamic writing. A profusion of similar scorings may be observed upon the Ballydorragh stone, first noticed by Mr. Du Noyer; and numerous examples occur in the "Lettered Cave" at Knockmore, and elsewhere. Fig. 4, in the same sheet, represents a couple of lines, which, though placed at some distance above them, may possibly be associated with the group of crosslets already noticed. In sheet 2 will be found a third cross enclosed within a quadrangle, and exhibiting the Etruscan style of enrichment already described in Fig. 2, sheet 1. Immediately beneath occurs a four-lined figure, not unlike an early letter A, accompanied by a small, plain, primitive cross.

My aim at present is not to theorize, but simply to call the attention of the antiquaries of the Academy to the fact of the existence of these very curious designs. I may say, however, that the occurrence of an interwoven pattern in the so-called "Celtic" style, in connexion, and in absolute contact with the primitive cross usually found upon monuments of undoubtedly prehistoric character, forces the suggestion, either that our interlaced designs, in some cases at least, may be of much earlier date than that very usually assigned to them, or that the pagan style of scoring or of symbolic writing, such as we find exemplified at Dowth, Newgrange, Slieve-na-calliagh, and elsewhere, was used in Ireland down to a period subsequent to the introduction of Christianity. In either case the "Celtic" work at "Gillie's Hole" may be regarded as perhaps the oldest example of true interlacing pattern hitherto noticed in Ireland.

XL.—On the Occurrence of Mammalian Bones, Brown Coal, and Pebbles in Mineral Veins. By William K. Sullivan, Ph. D., Secretary of the R. I. Academy, and Professor of Chemistry in the Catholic University of Ireland, and Royal College of Science.

[Read November 30, 1868.]

That the mineral matters filling up veins must be newer than the rocks containing them is self-evident; but how much newer they may be is a question which is very difficult to answer. Are the mineral veins that occur in Silurian rocks, for instance, necessarily older than those occurring in carboniferous rocks? or in other words, does the

relative age of the containing rock also determine the relative age of the mineral vein? So long as geologists believed mineral veins to have been formed by sublimation from below, the answer to this question must have been in the affirmative, for the deeper the fissures, the nearer would be the source of the metallic sublimates. But when this hypothesis was shown by the gradual progress of mineralogy, and a more careful study of the question from a chemical point of view, to be untenable; and that the greater number, at all events, of mineral veins have been formed by precipitation from descending solutions, there was no longer any necessary connexion between the relative age of the containing rock and that of the vein. The fossils found in the rocks afford satisfactory evidence in most cases of their relative ages, but until within the last few years no fossils had been discovered in mineral deposits. In many places we find pseudomorphites of several metallic ores in the form of fossils; as at Wiesloch, in Baden, where we find the limestone of the muschelkalk, which is one mass of shells, converted into Smithsonite or zincic carbonate. Again, at Münsterappel, in Rhenish Bavaria, cinnebar is found coating fish impressions of Amblypterus, and in small crystals in the interior of Calamites. But the interchange between the calcic and zincic carbonates in the muschelkalk, and the infiltration of the mercuric solution may have taken place at any time since the deposition of the rocks in which the ores are found. These cases then afford no satisfactory evidence of the recent formation of mineral deposits in rocks of considerable geological age.

In a valuable paper on the Geology of Bolivia and Southern Peru, read to the Geological Society of London, in November, 1860, Mr. David Forbes mentions the occurrence of mammalian bones in the Santa Rosa mine, belonging to the group of copper mines, known as the Corocoro Mines. Professor Huxley, to whom Mr. Forbes submitted the portion of the bones which he succeeded in getting, has shown that the animal belonged to the camel tribe, and was closely related to the existing llama of the Andes. He named the species Macrauchenia Boliviensis. The bones are in some instances "almost converted into copper, or at least the pores are filled with that metal." Fossil wood has also been found at a considerable depth at the same mine. The occurrence of a post-pleiocene fossil in a mine in Permian rocks would settle the relative age of the mineral deposit if it occurred in the deposit itself. But at Santa Rosa this was not so. In the Corocoro cupriferous formation, as we learn from Mr. Forbes, the ore occurs disseminated irregularly in certain beds of sandstone which are of Permian age. The bones could not have occurred in these beds. Mr. Forbes suggests that the animal had fallen into a fissure and been subsequently covered up by the crumbling sandy *debrîs* of the adjacent rocks which had gradually consolidated. Into this fissure cupric solutions would naturally be always flowing from the action of water on the ores in the beds.

Interesting as this occurrence of bones undoubtedly is, it does not help us to determine the relative age of the metal in the sandstone,

which, so far as this evidence goes, may have been deposited when the rock was formed, or at any subsequent period.

In a paper by Mr. J. P. O'Reilly and myself, read to the Academy, November 11th, 1861*, and in a subsequent memoir on the geology and mineralogy of the Province of Santander, in the north of Spain, which we published in the "Atlantis"†, and afterwards as a separate work‡, we gave an account of a remarkable fissure in the limestone in the Valley of Udias, filled with hydrocarbonate of zinc, in which were imbedded numerous mammalian bones, and also teeth probably of Elephas Primigenius. These fossils fix the relative age of all the great deposits of hydrocarbonate of zinc in the Province of Santander. This is, therefore, the first instance in which the geological age of any ore has been determined with certainty. The hydrocarbonate of zinc and carbonate of lead are, however, secondary deposits derived from the decomposition of sulphides, whose age we are as yet unable to fix with perfect certainty. Though in the case of the ores of Comillas—blende, galena, and Smithsonite, or carbonate of zinc—the age of the hydrocarbonate enables us to approximately fix that of the ores just mentioned.

In August, 1867, I had an opportunity of seeing another instance of Mammalian bones imbedded in mineralized matter, of even more importance than the Udias fossils, because they occurred in a regular vein containing galena, in carboniferous limestone. The mine where the specimens which I now exhibit were found is one of a group of mines around Stolberg, in Rhenish Prussia, and known as the Albertsgrube. The carboniferous limestone at this place, which is not far from Hastenrath, forms a saddle, resting on Devonian sandstone. In this limestone five lodes are met with in the workings at the Albert Mine. One of these, in its higher parts, consists of yellow clay, more or less mixed with sand. Lower down calc spar in large crystals, with imbedded crystals of galena, is associated with this clay. Galena also occurs in the clay in lumps, which are often one hundred pounds weight. This galena is sometimes associated with a kind of hard calc sinter, and some granular concretions of cerussite, or plumbic carbonate, are found on the galena. The latter mineral is also found by itself in the clay, under circumstances analogous to those under which it occurs in the mines of Santander; it, however, gradually disappears in depth.

In a part of this vein, and at a considerable depth, a thin band of what looks like the fine mud of very dense peat or brown coal, more or less mixed with fine sand, occurs. This band is generally only a couple of inches thick; but the coaly substance is here and there diffused through the clay and sand for some extent. Some of the calc sinter in its neighbourhood looks like a soft black limestone, owing to

---

* "Proceedings of the Royal Irish Academy," vol. viii., p. 9.

† "Atlantis," vol. iv., p. 378.

‡ "Notes on the Geology and Mineralogy of the Spanish Provinces of Santander and Madrid." London, 1863, p. 66.

the amount of the mud mixed up with it. Small stems of herbaceous plants or grass are sometimes found through this sinter. Where the sand predominates the black mass looks like the fine quartz sand and peat mud which may be seen mingled in the bed of a mountain stream. In some cases the sand is consolidated into a very friable sandstone-like mass. On a specimen of the latter exhibited to the Academy are a number of cubical crystals of galena, the upper faces of which are nearly one square centimetre in size. These crystals consist of thin shells of galena filled up with the brown coal. The galena on the surface of the calc sinter found in the neighbourhood of the brown coal is also intimately mixed up with that substance. The formation of crystals of galena around the brown coal proves beyond all doubt that the deposition of this part of the galena was posterior to the brown coal. The whole vein is clearly of very modern origin, and formed by the filling in of a fissure by matters borne mechanically, as well as in solution, by water into it. But what makes this perfectly certain is, the occurrence of small pieces of wood in the brown coal band. One of the proprietors of the mine, himself a practical miner, and who obligingly conducted me during three or four hours through the workings, showed me a piece of coniferous wood several inches long which he found in it. The bits which I observed here and there were extremely small. But more important still is the occurrence of Mammalian bones in it, of which I am fortunately able to exhibit a piece of one to the Academy. This bone is quite black from the action of the carboniferous matter, and contains some lead, due, no doubt, to the water containing lead in solution, and by which the vein was mineralized. The quantity of lead is very small, however—there not having been the same favourable conditions for effecting an interchange between the lead and the calcium of the bone, as in the case of the bones containing zincic phosphate from the Dolores cave in the valley of Udias in Spain above alluded to.

Some time before my visit a good many bones had been found at the Albertsgrube; they were presented to the University of Bonn. Herr von Dechen mentions this fact, as well as the occurrence of the brown coal, in his "Orographisch Geognostische Uebersicht des Regierungs Bezirks Aachen," which is a model of what a geological account of a district, written for practical purposes, ought to be. He there states that the bones belonged to a small species of Hippopotamos. I have not seen any other account of those important fossils.

Among the specimens from the same mine exhibited to the Academy are two others of considerable interest. One is a specimen of stalactitic pyrites, which is as truly the result of deposition from solution as any stalactite of a carbonate I have ever seen. The other is a rolled chalk flint found in the yellow clay forming the principal matrix or material of the lode. This chalk flint, and perhaps a good deal of the clay, comes from the denudation of the cretaceous rocks to the north and west. It may be worth mentioning that there is a considerable deposit of soft brown coal to the eastward; others of the same kind

may have also existed, which are now denuded. In connexion with the occurrence of this chalk flint, I may notice an interesting lode at the Brenessel Stockwerk, in the same district. The lode in question lies at a considerable depth in dolomitic limestone, and consists—first, of a band of blackish clay; then of a band of reddish clay, from one to two feet thick, containing small pieces of galena and cerussite. The blackish clay appears to be merely this clay mixed with brown coal or dense peat mud, like the substance found at Albertsgrube. On the reddish clay lies a layer of white quartz sand. This lode resembles in many ways the dykes of clay and white sand, sometimes associated with a band of hematite of considerable thickness, which are found in the carboniferous limestone of Ireland. There seems very little doubt that the sand and clay were washed into a fissure in the same manner as the brown coal, chalk, flint, and bones of the Albertsgrube.

The occurrence of pebbles, and other evidence of aqueous action in veins, have not attracted the attention they ought, chiefly because, on the one hand, the pebbles were found by practical miners, who did not see their value, and next, because the sublimation theory so affected the views of geologists, that they heeded not the evidence around them in every mine of aqueous action. Among the specimens which are exhibited to the Academy is a rolled pebble, found at the depth of about forty metres in the Dreikönigszug mine, on the Potzberg, near Kussel, in Rhenish Bavaria. This mine, which is worked in a kind of sandstone, permeated by cinnabar or mercuric sulphide, and yielding from 0·005 to 0·01 of mercury, has been carried down to a considerable depth. More than forty years ago, when M. Brard visited it, it had attained a depth of two hundred metres. The pebble is quartz, and is coated with crystallized cinnabar, so that the mineral was formed after the pebble had fallen, or been washed into the fissure in the sandstone.